The Bioscan 10(1): 147-151, 2015
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

EFFECT OF WEED MANAGEMENT ON GROWTH, YIELDS, WEED INDICES AND SOIL WEED SEEDBANK IN *RABI* FENNEL (*FOENICULUM VULGARE*)

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KEYWORDS
Foeniculum vulgare
Weed indices
Weed seedbank
Pendimethalin
Oxadiargyl
Glyphosate

Received on :
09.10.2014

Accepted on :
04.01.2015

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ABSTRACT
A field experiment was conducted during *rabi* season of 2011-12 at Instruction Farm, Junagadh Agricultural University, Junagadh – 362001 (Gujarat) on clayey soil to find out most effective method of weed control and to manage weed seedbank in *rabi* fennel. Results revealed that, significantly the higher plant height (153.1 cm), number of branches/plant (7.1), number of umbels/plant (12.7), number of seeds/umbellate (25.5), test weight (7.30 g), seed weight/plant (31.10 g) and seed (1841 kg/ha) and stover (4512 kg/ha) yields of fennel were recorded with weed free treatment, which was at par with pre-emergence (PRE) application of pendimethalin 0.90 kg/ha + post-emergence (POE) application of fenoxaprop-ethyl 75 g/ha at 45 DAS, pendimethalin PRE + hand weeding (HW) at 45 DAS and HW twice at 15 and 45 DAS. Besides weed free and HW twice treatments, lowest weed density and dry weight of weeds at harvest recorded with PRE of pendimethalin + HW (84 kg/ha), which was comparable to PRE pendimethalin + POE fenoxaprop-ethyl (196 kg/ha), PRE pendimethalin + POE oxadiargyl (104 kg/ha). Due to less cultivation cost as compared to weed free, these treatments also exhibited highest net returns (Rs. 81,442 and 81,993) and B : C ratio (3.21 and 3.22) as a result of lower weed index (0.91 and 0.52%) and higher weed control efficiency (93.31 and 84.30%), respectively. The highest depletion of weed seedbank (65%) was observed with pendimethalin + HW. So for effective management of weeds and weed seedbank along with better growth, yield attributes and profitable production of *rabi* fennel can be obtained by keeping the crop weed free throughout crop period or HW twice or PRE pendimethalin + HW or PRE pendimethalin + POE fenoxaprop-ethyl.

INTRODUCTION

India occupies prime position in seed spices and plays very important role in earning foreign exchange through export of seed spices. India is the world's largest producer, consumer and exporter of the spices. Fennel, *Foeniculum vulgare* Mill. (Family *Apiaceae*), a native of southern Europe and Mediterranean area, is an important seed spice. It is commonly known as '*Saunf*' or '*Badi saunf*' and in Gujarat it is known as '*Variari*'. Gujarat ranks first with respect to production and productivity in India. Area under *rabi* fennel is increasing day by day, because of more profitable than other *rabi* crops like wheat, gram, cumin, mustard etc. Lack of production technologies and weed control particularly for *rabi* fennel are important constraints in boosting up the production. Weeds spread easily, because of their enormous seed production and once established are not easily eradicated. Life cycle of most of them coincide with that of crop they invade, thus ensuring mixing of their seed with those of the crops. (Mahroof *et al.*, 2009). Initial slow growth of seed spices leads to severe weed crop competition and reduces growth as well as yield as high as 91.4% (Mali and Suwalka, 1987). Application of herbicides in fennel effectively controls the weeds and increases seed yield from 43.2 to 86.9 % (Voevodin and Borisenko, 1981). Therefore, field should be kept weed free at initial stage of crop establishment by employing available weed control methods. Though manual weeding is commonly employed practice but availability of labour itself is a problem and it requires high drudgery and is a costly practice. Therefore, it is essential to find out an appropriate and economical method of weed control to keep fennel fields weed free at the critical stages of crop-weed competition. Considering the facts and views highlighted above, the present field experiment was planned and conducted with objectives *viz.* 1) to evaluate the efficacy of different herbicides for control of weeds, 2) to study the effect of different weed management treatments on growth, yield attributes, yield and dynamics of weed seedbank under the influence of different weed management treatments and 3) to find out an economical weed management practice.

Soil weed seedbank is reserve of viable seeds present on the surface and in the soil. It consists of new seeds recently shed by a weed plant as well as older seeds that have persisted in the soil for several years. The seedbank is an indicator of past and present weed populations in soil. It is the main source of weeds in agricultural fields. Therefore, knowledge of seedbank dynamics can help in designing weed management practices related to a particular microclimate in an area. Very meagre efforts were made to estimate weed seedbank in soil and practically no research work was carried out in Gujarat regarding weed seedbank estimation under the influence of

different weed management practices. With this view, a seedbank study was also conducted.

MATERIALS AND METHODS

A field experiment was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh-362001 (Gujarat, India) during *rabi* season of 2011-12. The soil of experimental field was clayey in texture, slightly alkaline in reaction (pH 8.0 and EC 0.56 dS/m), low in available N (238 kg/ha), medium in available P_2O_5 (36.8 kg/ha) and K_2O (221 kg/ha). The experiment comprised ten treatments, *viz.*, pendimethalin 0.90 kg/ha as pre-emergence (PRE) + hand weeding (HW) at 45 DAS, oxadiargyl 75 g/ha as early post-emergence (POE) at 7 DAS + HW at 45 DAS, glyphosate 1.0 kg/ha as early POE at 7 DAS + HW at 45 DAS, pendimethalin 0.90 kg/ha as PRE + quizalofop-ethyl 40 g/ha as POE at 45 DAS, pendimethalin 0.90 kg/ha as PRE + fenoxaprop-ethyl 75 g/ha as POE at 45 DAS, pendimethalin 0.90 kg/ha as PRE + propaquizafop 75 g/ha as POE at 45 DAS, pendimethalin 0.90 kg/ha as PRE + oxadiargyl 75 g/ha as POE at 45 DAS, HW twice at 15 and 45 DAS, weed free and unweeded check were laid in randomized block design with three replications. The mean maximum and minimum temperature during the crop growth and development period ranged between 27.5 to 39.9°C and 9.4 to 22.1°C, respectively. The range of average relative humidity, bright sun shine, wind speed and daily evaporation was 25.6-57.0%, 4.8-10.2 h, 2.4-6.9 km/h and 3.8-10.7 mm, respectively. The fennel variety 'GF-11' was sown in second week of November at a spacing of 60 × 20 cm using seed rate of 8 kg/ha and fertilized with 90-30-0 kg N-P_2O_5-K_2O/ha by applying half dose of N and full doses of P as basal application at sowing and remaining half dose of N was top-dressed in two equal splits at 45 and 75 DAS and crop harvested at first week of April. All the standard package of practices including appropriate plant protection measures were followed throughout the cropping season. Herbicidal solutions as PRE at 2 DAS and POE application at 45 DAS were sprayed with the help of knapsack sprayer using flat fan nozzle and a spray volume of 500 l/ha. As per schedule hand weeding in the respective plots was done manually. In weed free plots, the weeds were removed manually after every ten days for ensuring weed free condition. Data on species wise weed count at 30 DAS, 60 DAS and at harvest by counting weeds present in 1m × 1m quadrate, relative weed density and dry weight of weeds. For the estimation of weed seedbank, the soil samples were drawn by core sampler of 2 cm in diameter from 15 cm depth as per the FAO protocol (Forcella *et al.*, 2011). Each soil core was individually bagged and numbered. Seed extraction should be done by sieving of the samples through copper sieves of 5 mm in diameter followed by their rinsing by water and sieving of the samples through a descending series of sieves up to 0.5 mm in diameter. Seeds were then dried at the room temperature and separated manually and sample-wise seed count was recorded. The experimental data recorded for growth parameters, yield attributes and yield parameters economics and correlation were statistically analyzed for level of significance. The weed index (WI) was calculated by formula,

$$WI = \frac{Y_{WF} - Y_T}{Y_{WF}} X\ 100$$

Where; Y_{WF} and Y_T are the yield from weed-free plot and yield from treated plot, respectively (Gill and Kumar, 1969). Weed control efficiency (%) can be computed by using formula,

$$WCE\ (\%) = \frac{DW_C - DW_T}{DW_C} X\ 100$$

Where, DW_C = Dry matter accumulation of weeds in unweeded control, DW_T = Dry matter accumulation of weeds in treated plot, (Kondap and Upadhyay, 1985). The herbicide efficiency index (HEI) was calculated formula

$$HEI = \frac{Y_t - Y_c}{Y_c} X\ 100$$

Where, Y_t = Yield from treated plot, Y_c = Yield from unweeded control plot, (Krishnamurthy *et al.*, 1995) and Relative weed density was calculated as per formula, (Gupta, 2011).

$$Relative\ Density = \frac{NP_w}{NP_{tw}} X\ 100$$

Where, NPw = mean population of the weed species in question per unit area (m^2) and NPtw = mean population of all the weed species combined present per unit area (m^2).

RESULTS AND DISCUSSION

Crop growth and yield

Different weed management treatments significantly influenced the different growth and yield attributes of fennel crop. Perusal of data revealed that higher plant height (153.1 cm), number of branches/plant (7.1), number of umbels/plant (12.7), number of seeds/umbellate (25.5), test weight (7.30 g), seed weight per plant (31.10 g), and seed (1841 kg/ha) and stover (4512 kg/ha) were recorded with weed free treatment, which was at par with pendimethalin as PRE + fenoxaprop-ethyl as POE, pendimethalin as PRE + HW at 45 DAS and HW twice (Table 1). The improved growth and yield under these treatments might be due to effective weed control resulting in lesser competition of weeds which might have resulted in the better utilization of nutrients and moisture available in the soil by crop leading to increased rate of photosynthesis and supply of photosynthates to various metabolic sinks. These findings are in agreement with those of Meena and Mehta (2009), Nagar *et al.* (2009) and Channappagoudar *et al.* (2013).

Weed flora

The weed flora observed in the experimental field constituted monocot weeds *viz.*, *Brachiaria* spp. (7.67%), *Indigoflora glandulosa* L.(7.00%), *Asphodelus tenuifolius* L. Cav. (5.00%) and *Dactyloctenium aegyptium* Beauv (1.33%), dicot weeds *viz.*, *Digera arvensis* Forsk (18.67%), *Chenopodium album* L. (16.33%), *Physalis minima* L. (7.67%), *Portulaca oleracea* L. (5.67%), *Euphorbia hirta* L. (4.00%) and *Leucas aspera* Spreng (1.33%), and sedge weed *viz.*,*Cyperus rotundus* L. (25.33%).

Table 1: Effect of different treatments on plant growth, yield attributes and yield of fennel

Treatments	Plant height (cm)	Branches/ plant	Umbels /plant	Umbellates / umbel	Seeds/ umbellate	1000-seed weight(g)	Seed weight/ plant (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
Pendimethalin +HW	146.3	6.5	11.3	23.3	24.1	6.57	27.87	1824	4447
Oxadiargyl +HW	130.9	5.0	7.7	18.9	19.1	6.02	14.27	1045	2947
Glyphosate +HW	127.7	4.2	7.2	18.7	19.1	6.01	13.77	1086	2994
Pendimethalin + Quizalofop-ethyl	137.1	4.9	8.4	21.9	20.1	6.05	15.47	1321	3664
Pendimethalin + Fenoxaprop-ethyl	149.9	6.6	12.0	23.0	25.3	6.62	29.33	1831	4507
Pendimethalin + Propaquizafop	136.5	5.0	8.2	21.3	19.1	6.03	16.07	1325	3644
Pendimethalin + Oxadiargyl	137.4	5.2	8.3	22.9	19.2	6.14	15.43	1315	3557
HW twice	146.6	6.7	10.6	23.6	23.3	6.52	28.00	1799	4496
Weed free	153.1	7.1	12.7	23.7	25.5	7.30	31.10	1841	4512
Unweeded check	126.6	3.9	6.3	17.1	16.2	5.71	10.17	921	2668
C.D. (P=0.05)	14.7	1.0	2.2	NS	4.1	0.82	4.27	368.56	821

These findings are in agreement with those of Goud *et al*. (2013).

Weed parameters

The results indicated that application of different weed management practices significantly influenced weed population (Table 2) and dry weight of weed (Table 5). Among the weed management treatments, maximum weed population and dry weight of weeds (1248 kg/ha) at harvest were recorded in unweeded check. Besides, weed free treatment, the lowest weed population was recorded with HW twice, which remained at par with pendimethalin as PRE + HW and pendimethalin as PRE + fenoxaprop-ethyl as POE. Next to weed free, HW twice or pendimethalin as PRE + HW or pendimethalin PRE + oxadiargyl as POE reduced dry weight of weeds over unweeded check. This can be attributed to the effective control of early as well as late flushes of weeds and did not allow weeds to regenerate, which reflected in less number of weeds and ultimately lower weed biomass. In addition to this, dense crop canopy might have suppressed weed growth and ultimately less biomass. The unweeded check recorded significantly the highest dry weight of weeds owing to uncontrolled condition favoured luxurious weed growth leading to increased weed dry matter. These findings are in conformity with those reported by Thakral *et al*. (2007), Meena and Mehta (2009) and Channappagoudar *et al*. (2013).

Besides weed free treatment, the highest WCE (93.63) was obtained with HW twice, followed by pendimethalin as PRE + HW (93.31). Next to weed free, minimum WI (0.52) and maximum HEI (98.84%)were obtained with pendimethalin PRE + fenoxaprop-ethyl POE, closely followed by pendimethalin PRE + HW (0.91 and 98.06%). This might be due to elimination of weeds by manual weeding and herbicides. The combined effect on dry weight of weeds and seed yield under these treatments might have been responsible for excellent weed indices. Whereas the highest WI (49.97%) observed in the unweeded check indicated that reduction in seed yield by about 50.0 per cent due to uncontrolled weeds as compared to weed free. The result confirms the findings of Meena and Mehta (2009), Nagar *et al*. (2009) and Yadav *et al*. (2010).

Relative weed density

The data on relative density percentage of monocot, dicot and sedge weed species at 30 DAS, 60 DAS and at harvest (Table 3) and concerning the relative density of individual weed species at harvest indicated that *Cyperus rotundus* L. was found to be the most densely populated weed in the experimental field of fennel, followed by *Chenopodium album* L., *Digera arvensis* Forsk and *Asphodelus tenuifolius* L. Cav. While, remaining weeds presented in experimental field which were not present at a much larger extent are also listed in Table 4.

Weed seedbank

The dynamics of weed seedbank in soil drastically influenced by different weed management treatments (Table 3). The lowest weed seedbank was recorded with pendimethalin as PRE + HW (Depletion of 65%). Pendimethalin as PRE controlled weeds right from the start and weeds those escaped and emerged later were controlled by hand weeding at 45 DAS, hence did not allow to set the weed seeds, which was almost same to the weed free and remained at par with pendimethalin as PRE + oxadiargyl as POE and HW twice. The treatments *viz*., pendimethalin as PRE+ quizalofop-ethyl as POE, pendimethalin as PRE + fenoxaprop-ethyl as POE and pendimethalin as PRE + propaquizafop as POE were found to increase weed seedbank. This might be ascribed to the fact that the post-emergent herbicides *viz*., quizalofop-ethyl, fenoxaprop-ethyl and propaquizafop are grassy weed killers, leaving dicot weeds to produce seeds. The unweeded check recorded the highest size of weed seedbank due to production of large number of weed seeds under uncontrolled condition leading to 978 % increase in the initial weed seedbank. The result confirms the findings of Angiras *et al*. (2010).

Correlation studies

Results revealed that plant height at harvest, number of branches/plant, number of umbels/plant, number of umbellate/ umbel, number of seeds /umbellate, test weight and seed weight/plant showed positive and significant correlation with seed yield of fennel, while weed parameters *viz*. monocots, dicots and sedge weeds count at harvest, and dry weight of weed exhibited negative and significant relationship with seed yield of fennel. The positive correlation between seed yield and plant height at harvest was the highest (0.9768), followed by seed weight/plant (0.9758), number of umbels/plant (0.9693), number of branches/plant (0.9655), number of

Table 2: Effect of weed management on weed population

Treatments	Monocot weeds/m² at			Dicot weeds/m² at			Sedge weeds/m² at			Total weeds/m² at		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
Pendimethalin + HW	1.22(1.00)	1.17(1.00)	1.05(0.67)	2.27(4.67)	1.34(1.33)	1.44(1.67)	2.60(6.33)	1.56(2.00)	1.66(2.33)	3.53 (12.00)	2.18 (4.33)	2.22 (4.67)
Oxadiargyl + HW	1.34(1.33)	1.68(2.33)	1.77(2.67)	2.38(5.33)	2.54(6.00)	2.40(5.33)	3.27(10.33)	2.67(6.67)	2.68(6.67)	4.14 (17.00)	3.94 (15.00)	3.89 (14.67)
Glyphosate + HW	1.86(3.00)	1.84(3.00)	1.56(2.00)	4.22(17.33)	2.57(6.67)	2.59(6.33)	2.53(6.33)	2.18(4.33)	2.78(7.33)	5.21 (26.67)	3.79 (14.00)	4.02 (15.67)
Pendimethalin + Quizalofop-ethyl	1.46(1.67)	2.60(6.33)	2.61(6.33)	2.66(6.67)	3.67(13.00)	3.39(11.00)	3.36(11.00)	3.76(13.67)	3.52(12.00)	4.44 (19.33)	5.78 (33.00)	5.45 (29.33)
Pendimethalin + Fenoxaprop-ethyl	1.34(1.33)	1.22(1.00)	1.17(1.00)	2.65(6.67)	3.58(12.33)	3.13(9.33)	2.67(6.67)	1.58(2.00)	1.72(2.67)	3.89 (14.67)	3.98 (15.33)	3.67 (13.00)
Pendimethalin + Propaquizafop	1.46(1.67)	2.04(3.67)	1.74(2.67)	2.54(6.00)	3.76(13.67)	3.52(12.00)	3.22(10.00)	2.95(8.33)	2.72(7.00)	4.26 (17.67)	5.10 (25.67)	4.69 (21.67)
Pendimethalin + Oxadiargyl	1.34(1.33)	2.08(4.00)	1.68(2.33)	2.81(7.67)	0.88(0.33)	1.05(0.67)	3.13(9.33)	2.85(7.67)	2.80(7.33)	4.33 (18.33)	3.53 (12.00)	3.29 (10.33)
HW twice	1.05(0.67)	1.22(1.00)	1.17(1.00)	1.34(1.33)	1.34(1.33)	1.44(1.67)	1.34(1.33)	1.34(1.33)	1.68(2.33)	1.95 (3.33)	2.04 (3.67)	2.33 (5.00)
Weed free	0.71(0)	0.71(0)	0.71(0)	0.71(0)	0.71(0)	0.88(0.33)	0.71(0)	0.88(0.33)	1.17(1.00)	0.71 (0)	0.88 (0.33)	1.34 (1.33)
Unweeded check	2.78(7.33)	4.41(19.00)	4.63(21.00)	5.95(35.33)	7.26(52.33)	7.33(53.67)	4.03(16.00)	4.93(24.67)	5.04(25.33)	7.67 (58.67)	9.82 (96.00)	10.02 (100.00)
C.D. (P=0.05)	0.41	0.52	0.51	0.73	0.71	0.67	0.77	0.71	0.72	0.69	0.50	0.45

Note: $\sqrt{X + 0.5}$ transformation (Figures in parenthesis are original values of weed count).

Table 3: Effect of weed management on relative weed density (%) and weed seedbank dynamics

Treatments	Relative weed density (%)											
	At 30 DAS			At 60 DAS			At Harvest		Weed seedbank/core			
	Monocot	Dicot	Sedge	Monocot	Dicot	Sedge	Monocot	Dicot	Sedge	Initial	Final	Addition(+) /Depletion(-)
Pendimethalin + HW	8.49	39.13	52.38	22.22	30.56	47.22	11.43	37.62	50.95	210	74	-136 (-65)
Oxadiargyl + HW	7.89	30.49	61.62	15.75	39.68	44.56	18.25	36.19	45.56	210	147	-63 (-30)
Glyphosate + HW	11.23	65.47	23.30	21.70	43.79	34.51	13.15	39.97	46.88	210	161	-49 (-23)
Pendimethalin + Quizalofop-ethyl	9.01	34.81	56.18	19.06	39.36	41.58	21.52	37.90	40.59	210	278	+ 68 (+ 32)
Pendimethalin + Fenoxaprop-ethyl	9.43	44.84	45.73	6.56	80.31	13.13	7.14	72.51	20.35	210	242	+ 32 (+ 15)
Pendimethalin + Propaquizafop	9.63	34.63	55.74	14.64	53.36	32.00	12.53	55.53	31.95	210	221	+ 11 (+ 5)
Pendimethalin + Oxadiargyl	7.47	40.99	51.54	32.56	2.56	64.88	22.42	6.36	71.21	210	99	-111 (-53)
HW twice	19.44	38.89	41.67	27.78	36.11	36.11	17.86	30.95	51.19	210	125	-85 (-40)
Weed free	0.00	0.00	0.00	0.00	0.00	33.33	0.00	33.33	66.67	210	76	-134 (-64)
Unweeded check	12.34	59.94	27.72	19.78	54.92	25.30	21.23	53.35	25.42	210	2264	+ 2054 (+ 978)
	C.D. (P=0.05) -		-	-	-	-	-	-	-	-	-	73 -

Note: (Figures in parenthesis are percent addition/depletion of seedbank in case of weed seedbank).

Table 4: Relative density of individual weed species at harvest

Treatments	Relative density (%)										
	Cyperusrotundus L.	*Chenopodium album L.*	*Digera.arvensis* Forsk	*Asphode lustenuifolius L. Cav.*	*Brachiaria Spp.*	*Indigoflora glandulosa L.*	*Physalis minima* L.	*Euphorbia hirta* L.	*Dactyloctenium aegyptium Beauv*	*Portulaca oleracea L.*	*Leucas aspera Spreng*
Pendimethalin + HW	49.89(2.33)	35.76(1.67)	0.00(0.00)	14.35(0.67)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Oxadiargyl + HW	45.47(6.67)	22.70(3.33)	2.25(0.33)	13.63(2.00)	4.57(0.67)	0.00(0.00)	0.00(0.00)	11.38(1.67)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Glyphosate + HW	46.81(7.33)	19.16(3.00)	17.05(2.67)	8.49(1.33)	4.28(0.67)	0.00(0.00)	2.11(0.33)	2.11(0.33)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Pendimethalin + Quizalofop-ethyl	40.91(12.00)	14.76(4.33)	22.74(6.67)	11.35(3.33)	1.13(0.33)	9.10(2.67)	0.00(0)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Pendimethalin + Fenoxaprop-ethyl	20.54(2.67)	25.62(3.33)	43.62(5.67)	7.69(1.00)	0.00(0.00)	0.00(0.00)	2.54(0.33)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Pendimethalin + Propaquizafop	32.32(7.00)	15.37(3.33)	30.79(6.67)	10.76(2.33)	0.00(0.00)	1.52(0.33)	9.23(2.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Pendimethalin + Oxadiargyl	70.96(7.33)	0.00(0.00)	6.49(0.67)	3.19(0.33)	12.88(1.33)	6.49(0.67)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
HW twice	46.69(2.33)	20.04(1.00)	13.43(0.67)	6.61(0.33)	6.61(0.33)	0.00(0.00)	0.00(0.00)	0.00(0.00)	6.61(0.33)	0.00(0.00)	0.00(0.00)
Weed free	75.19(1.00)	24.81(0.33)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Unweeded check	25.33(25.33)	16.33 (16.33)	18.67(18.67)	5.00(5.00)	7.67(7.67)	7.00(7.00)	7.67(7.67)	4.00(4.00)	1.33(1.33)	5.67(5.67)	1.33(1.33)

Note: Figures in parenthesis indicate individual weed species count per m².

Table 5: Effect of weed management practices on dry weight of weeds, weed indices and economics of fennel

Treatments	Dry weight of weeds (kg/ha)	Weed index (%)	Weed control efficiency(%)	Herbicidal efficiency index (%)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	B : C ratio
Pendimethalin + HW	84	0.91	93.31	98.06	36882	81442	3.21
Oxadiargyl + HW	237	43.22	81.01	13.49	36976	31622	1.86
Glyphosate + HW	282	41.02	77.40	17.88	36402	34717	1.95
Pendimethalin + Quizalofop-ethyl	494	28.23	60.43	43.45	36745	49841	2.36
Pendimethalin + Fenoxaprop-ethyl	196	0.52	84.30	98.84	36882	81993	3.22
Pendimethalin + Propaquizafop	303	28.03	75.73	43.84	36711	50052	2.36
Pendimethalin + Oxadiargyl	104	28.54	91.66	42.82	36840	49186	2.34
HW twice	80	2.28	93.63	-	36608	80301	3.19
Weed free	0	0.00	100.00	-	39751	79703	3.01
Unweeded check	1248	49.97	0.00	-	33603	26984	1.80
C.D. (P=0.05)	84	-	-	-	-	-	-

Market Price:		Herbicides	Rs./kg or lit	Herbicides	Rs./kg or lit
Commodity	Rs./kg	Pendimethalin	: 400	Quizalofop-ethyl	: 1350
Fennel seeds	: 60.00	Oxadiargyl	: 930	Fenoxaprop-ethyl	: 1500
Fennel stover	: 2.00	Glyphosate	: 270	Propaquizafop	: 140

seeds/umbellate (0.9584), number of umbellate/umbel (0.9050) and test weight (0.8747), which attributed correspondingly 95.41, 95.21, 93.96, 93.21, 91.85, 81.90 and 76.51 per cent variation in seed yield of fennel. While the negative correlation between seed yield and sedge weeds count at harvest was the highest (-0.7589), followed by dry weight of weeds (-0.6639), total weeds count at harvest (-0.6314), monocot weeds count at harvest (-0.6214) and dicot weeds count at harvest (-0.5604), which ascribed accordingly 57.60, 44.07, 39.86, 38.61 and 31.40 per cent deviation in seed yield of fennel.

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